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Amphibian Habitat Usage of Two Restored Bogs in Shady Valley, Johnson County, Tennessee.

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Amphibian Habitat Usage of Two Restored Bogs in Shady Valley,
Johnson County, Tennessee

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by
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ABSTRACT

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Adjacent terrestrial habitat surrounding wetlands are critical for the survival and success of many species that use them. The primary purpose of this study was to determine amphibian movement from adjacent habitats into Orchard Bog, a restored bog located in Shady Valley, Johnson County, Tennessee. In addition, a secondary bog, Quarry Bog, was also studied determining baseline presence/absence data.

A total of 16 species from six families were observed throughout the study sites. Seven species of anurans, Bufonidae, Hylidae, and Ranidae and nine species of caudates in the families Plethodontidae, Ambystomatidae and Salamandridae were identified. Fourteen of the 16 species were found within Orchard Bog.

Data collected can be used to help determine more beneficial land acquisitions and management strategies. Survey methods included pitfall traps, funnel traps, coverboard arrays, and opportunistic surveys.

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CHAPTER 1

INTRODUCTION

Terrestrial habitats that surround or are adjacent to wetlands are crucial for the survival and success of species that exist within. Areas surrounding wetlands are slowly gaining the recognition that is needed to show that they are critical to the survival and success of many species (Roe 2007). With an increase in the decline of amphibian diversity due to loss of and alterations to their habitat, it is crucial that we examine the roles that these surrounding areas play to the survival of species (Blaustein et al. 1994; Alford and Richards 1999). Due to the complex life cycles of amphibians, limited mobility, and a high degree of philopatry, they may be exceedingly sensitive to changes in habitat from urbanization or agricultural practices (Blaustein et al. 1994; Semlitsch 2002).

The primary goal of this project is to determine amphibian habitat usage and movement from adjacent habitats into Orchard Bog. Habitats surrounding this preserve include a stream area, woodland, and pastureland (Figure 1). Knowledge of amphibian movement and use of surrounding habitats will be useful for future land acquisitions made by the Nature Conservancy.

It is widely understood that surrounding buffer zone areas help to protect core wetland species from land-use practices such as agricultural, building, and urbanization and also from a variety of pollutants (Semlitsch and Jenson 2001) and that many species have a high degree of dependence on these area. Many surrounding habitat areas are critical to the survival of semi-aquatic and terrestrial species (Semlitsch and Bodie 2003) and there is an association between local diversity and surrounding landscape composition (Laan and Verboom 1990; Knutson et al. 1999; Porej et al. 2004).

Surrounding terrestrial habitat acts as a natural filter and helps to protect core habitat from human activities that can be detrimental to many species (Semlitsch and Bodie 2003). It is gradually being acknowledged that these surrounding areas are not only an important filtering mechanism that remove pollutants and chemicals from the soils and water but that these outer regions are also significant in the preservation and management of semi-aquatic species. Surrounding terrestrial areas have been shown to support a broad range of species including amphibians, reptiles, and mammals (Rudolph and Dickson 1990; Spackman and Hughes 1995; Semlitsch and Bodie 2003).

Lands that have been converted to agricultural uses are typically unattractive to most amphibians because these areas are generally open and dry. Most amphibians choose refuge in moist areas due to physiological constraints (Gibbs 1998); therefore, when restoration of these areas occurs, it may require a considerable amount of time before areas can be reestablished.

Although some amphibians most readily choose moist areas as their primary habitat, they will at certain times use both aquatic and terrestrial habitats at some point during life cycles. Until recently, terrestrial buffer zones were thought to be of secondary importance in management practices. It is now being realized that these areas serve as primary, rather than secondary, habitat to some species (Semlitsch and Jenson 2001). Many species use the aquatic areas for only short amounts of time, ranging from a few days to a few weeks, to breed and lay eggs. For the remaining portion of the year they emigrate to surrounding habitats to forage and overwinter. (Semlitsch and Bodie 2003).

An understanding of the life cycle of many of these species can help to determine best management practices for future conservation and preservation efforts (Semlitsch and Jenson 2001).

It was the understanding of many that only wetland habitats were necessary for survival, but it is becoming increasingly apparent that terrestrial zones are also crucial for the success and maintenance of stable populations (Semlitsch 1998). Many studies have examined the exact role that both habitats play, with increased importance being placed on terrestrial habitat adjacent to wetlands (Burke and Gibbons 1995; Semlitsch 1998).

Because many semi-aquatic organisms also use adjacent terrestrial habitats, it is essential to their survival that data be collected pertaining to use of these areas. It is also important to look at these terrestrial zones and determine if they are being used for more significant purposes then was initially thought. They may not simply be areas that species occasionally use but may instead be areas critical to a successful life cycle (Semlitsch 1998).

Another component of the project compares species diversity between a restored bog of 4 years, a relatively new bog of approximately 1 1/2 years, and a non-bog habitat (pasture) to see if amphibian recolonization rates will occur more readily within a certain habitat. This will present useful baseline data on species diversity as well as data relevant to specific habitat types. The results of the study may also provide data that indicate the success of the restoration efforts that have taken place at both Orchard Bog and Quarry Bog over the last 4 years and 1 ½ years respectively.

BEAVERDAM CREEK

PASTURE

WOODLOT

Figure 1 Images of Habitats Surrounding Orchard Bog

CHAPTER 2

MATERIALS AND METHODS

Study Sites

The study sites are located in Shady Valley, Johnson County, Tennessee in the extreme northeastern tip of the state. I used two bogs, Orchard Bog and Quarry Bog, and one control site over the course of my study which took place from early spring of 2001 until late summer of 2002. The valley is surrounded by the Holston, Iron, and Cross Mountains and is located in the Blue Ridge Province at an elevation of approximately 2860 feet. Iron Mountain forms the eastern boundary and forms a very well defined ridge that reaches from Virginia to Watauga Dam in Carter County, Tennessee. Holston Mountain extends south from Damascus, Virginia to Elizabethton, Tennessee and Cross Mountain reaches three miles wide between the Iron and Holston in the southwest (Coffey and Shumate 1999).

Orchard Bog and Quarry Bog are indicators of a peatland community which is a globally rare ecosystem. After the last glacial event, Shady Valley was able to retain rare wetland habitats now seen primarily in more northerly environments (Nature Conservancy Shady Valley Program http). In 1996 the Tennessee Chapter of the Nature Conservancy purchased 1.5 acres to create the Orchard Bog Preserve. Since that time, additional land has been purchased and Orchard Bog now contains 169 acres. When this study was conducted the bog consisted of approximately 73 acres. Quarry Bog consisted of 65 acres and the control site consisted of approximately 50 acres.

The bogs were drained in the early 1930s by the Works Project Administration

(WPA) for the installation of roads and railways as well as for agricultural purposes such as farmland and grazing (Coffey and Shumate 1999). In addition, much of the timber was harvested and Beaverdam Creek, a tributary of the South Fork Holston River, was altered by channelization. The river, which is essential to the hydrology of the area, drains the valley as it flows to the north.

Although their were drastic changes to the valley during the 1930s and drainage ditches had been cut over a vast majority of the land, it was stated by Ganier and Tyler in 1934 that areas remained "boggy" due to the large amounts of water seeping from the mountains surrounding the valley. Ditches still ran full of water even though surrounding lands were dry from lack of precipitation. Additional drainage plans were completed in 1963 by the U.S. Department of Agriculture's Soil Conservation Service and by 1965, additional channeling and ditching was completed (Coffey and Shumate 1999).

The Control Site was an area that was primarily used for agriculture purposes, mostly hay production. Beaverdam Creek borders one side of the property and near the creek area higher vegetation was present. Timber also bordered one edge of the property.

Survey Methods

Orchard Bog, Quarry Bog, and the control site were surveyed during a period of 13 months for a total of 33 visits. All three sites were surveyed during each visit. The distribution of visits is shown monthly in Table 1.

Table 1 Number of Survey Visits by Month and Year

Month/Year		Number of Visits
March	2002	2
April	2002	4
May	2002	3
June	2002	2
July	2002	2
August	2002	2
September	2002	2
October	2002	1
March	2003	3
April	2003	4
May	2003	4
June	2003	3
July	2003	1

Habitat usage was measured by setting up pitfall traps with drift fences and by using funnel traps in adjacent streams or waterways. A Visual Encounter Survey (VES) was used in Orchard Bog. A general survey was carried out in Quarry Bog, Orchard Bog, and a control site that consisted of a tract of pastureland that lies adjacent to Quarry Bog. Most surveying was done during opportunistic times between the hours of 5:00 PM and 11:00 PM when amphibian species are known to be more active.

The salamander portion of the study implemented various sampling techniques including the use of artificial and natural cover objects, pitfall traps with drift fences, funnel traps, as well as a simple visual search technique. Environmental data collected for this portion of the study also included time, temperature, wind speed, and precipitation within the last 24 hours. Precipitation data were collected from AccuWeather.com. Time, temperature, and wind speed were recorded on site using a digital handheld weather station.

Species diversity between the varying study sites was measured by implementing all survey methods. These measurements were applied to Orchard Bog that had a restoration age of approximately 4 years, Quarry Bog that had begun restoration process in the fall of 2000, and on pastureland adjacent to Quarry Bog in which no restoration efforts had been administered.

Pitfall Traps with Drift Fences

Each pitfall trap array measured approximately 10 meters in length with pitfall traps placed on the side of the drift fence away from the breeding area. Drift fences intercept amphibians and redirect them into a pitfall trap (Figure 2). Drift fences and pitfall traps have the ability to capture certain species much more readily than other sampling methods. Anurans that are extremely strong jumpers and climbers are more difficult to capture in pitfall traps than most terrestrial species. For this reason

five gallon buckets that measured (11.91" diameter x 14.50" high x 10.33" diameter at the bottom) were used to help prevent species from jumping out of traps after capture. Holes were drilled in the bottoms of buckets to prevent varying water levels from elevating them out of the ground. During the dry portions of the trapping season, leaf litter and wet sponges were placed in the bottom of traps to help prevent desiccation. A variety of small wood objects were placed in traps that held water to prevent drowning. Lids were slanted over tops of traps to help prevent escape.

Not all studies incorporate drift fences with the use of pitfall traps. However, when drift fences are used, traps will intercept several meters of ground rather than a few centimeters without drift fences (Corn 1994). For this study, drift fences were implemented with pitfall traps. Pitfall traps were made from five gallon plastic buckets. All traps were buried in the ground with the opening level with the surface of the ground. Lids were raised above the buckets when traps are open to help prevent captured species from escaping, prevent predation, and may have also helped to attract certain species. To decrease mortality rates, which were found to be fairly high in some studies, a layer of moist soil and debris was placed in the bottom of each trap (Corn, 1994, Heyer et al. 1994). This helped trapped animals avoid desiccation and helped to protect from possible predators.

The drift fences for each trap were constructed of aluminum flashing approximately 50 cm wide and 10 meters long. A trench of approximately 20 cm deep was dug for the desired length of the drift fence and then dirt was packed around the base to prevent species from escaping underneath. Figure 3 shows an image of a pitfall trap array with drift fence along with samples collected. Traps were placed along the side of the fence away from the breeding area to capture all species moving toward that site with no gaps between the fence and rim of the trap. All traps were numbered for data recording purposes (trap 1, trap 2, etc). Traps were opened in early afternoon and left open overnight. During rainy periods traps were left open continuously and checked every 8 to 16 hours. Captured species were identified and released on the opposite side of the fence to lower chances of recapture.

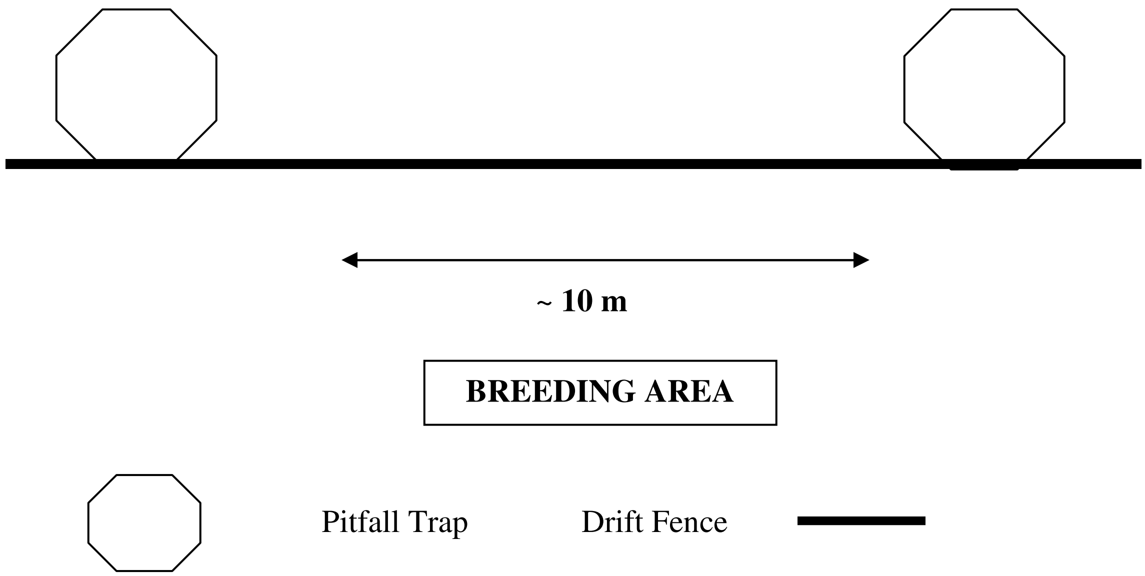

Figure 2 Pitfall Trap Array

<u>Funnel Traps</u>

The funnel traps used in this study were placed in streams or waterways adjacent to the pitfall traps. Traps were conical in shape with two inwardly directed funnel shaped openings (Figure 4). All traps were covered with window screening to prevent smaller captured individuals from escaping through sides and openings in walls. The openings on either end of the traps measured 20 centimeters in diameter.

Figure 3 Images of Pitfall Trap and Samples Collected

Figure 4 Image of Funnel Trap

Cover Boards

Artificial cover boards used in the study were made of oak and maple and measured approximately 1x12x18 inches. All boards were untreated. Boards were placed in a measured line transect with a minimum of 10 feet between each cover board. For each habitat type (creek, pasture, and woodlot), 15 cover boards were used for a total of 45 boards. Each artificial cover board was flagged and numbered (cb-1, cb-2, etc), so all surveyed species could be returned to their original cover board (Fernandes 2002). Boards were checked by quickly lifting and capturing all amphibians found underneath. Samples were identified and then replaced at the edge of the board.

Visual Encounter Survey

The VES used in this study was the randomized walk design (Heyer et al. 1994). Searches included cover objects being overturned such as rocks and logs that were then returned to their original position. This method was determined to be appropriate due to the relatively large size of the study area being sampled. All individuals encountered within one meter of the directional line were counted with relevant data for each individual being recorded. Several factors influence the results of a VES including weather conditions, time of day, and habitat conditions. Conditions were similar during all VES surveys (Heyer et al. 1994). Due to time and area constraints a minimum of 50 meters and maximum distance of 75 meters was chosen in which to carry out the VES.

Opportunistic Survey

Opportunistic nighttime surveys were also conducted. These were conducted along randomly selected transects and were done when both temperature and humidity conditions were favorable for surface activity by semi-aquatic and terrestrial species. Opportunistic surveys were used on all study areas: Orchard Bog, Quarry Bog, and the Control when weather conditions were similar.

CHAPTER 3
RESULTS

Throughout the study sites, 16 species were observed from six families. The six families were from two orders, Anura and Caudata (Table 2). Frogs and toads were the most abundant herpetofauna identified although there was greater diversity in species representation of caudates. Seven species of anurans were observed from the families Bufonidae, Hylidae, and Ranidae. Nine species of caudates from the families Plethodontidae, Ambystomatidae, and Salamandridae were also identified.

Table 2 Herpetofaunal Species List

Species identified from Shady Valley, Johnson County, Tennessee
Pitfall Traps, Funnel Traps, and Surveys
March 2002 – October 2002 and March 2003 – July 2003

CLASS: Amphibia

ORDER: Anura

FAMILY: Bufonidae

Bufo americanus – American Toad

FAMILY: Hylidae

Hyla versicolor or *Hyla chrysoscelis* – Gray Tree Frog / Copes Gray Treefrog

Pseudacris crucifer – Spring Peeper

Table 2 (continued)

FAMILY: Ranidae

Rana clamitans – Green Frog

Rana palustris – Pickeral Frog

Rana sylvatica – Wood Frog

Rana catesbeiana – American Bullfrog

ORDER: Caudata

FAMILY: Plethodontidae

Desmognathus ochrophaeus – Mountain Dusky Salamander

Desmognathus fuscus – Northern Dusky Salamander

Eurycea wilderae – Blue Ridge Two-lined Salamander

Plethodon cylindraceus – White-Spotted Slimy Salamander

Plethodon yonahlossee – Yonahlossee Salamander

Pseudotriton ruber – Red Salamander

Gyrinophilus porphyriticus – Spring Salamander

FAMILY: Ambystomatidae

Ambystoma maculatum – Spotted Salamander

FAMILY: Salamandridae

Notophthalmus viridescens – Red-Spotted Newt

Several habitat types are located within Orchard Bog including marsh or wetland, dry field, dry forest, and stream. Habitat characteristics of Quarry Bog are somewhat similar to Orchard Bog though there are notable differences in age. Habitat types located within this area include marsh or wetland, dry field, and stream. It is important to note that at the time of this study, a small portion of Quarry Bog was still actively being used for hay production. Nine species were encountered in Quarry Bog including six anuran species and four caudate species. Habitat characteristics of the control included stream and dry field. Three species of anurans were encountered within the Control site - *Bufo americanus, Pseudacris crucifer,* and *Rana catesbeiana.*

Occurrence of Species and Community Similarity

There were found to be differences in species composition in the three sites studied. Orchard Bog supported 14 different species, 10 species were identified in Quarry Bog and 3 species were identified in the Control Site. The most abundant of all species between the three sites was found to be *Pseudacris crucifer* with a total of 228 captured in both pitfall and funnel traps. Located within this study site, six families from two orders from the class Amphibia were supported (Table 3). Frogs were the most abundant herpetofauna with six species encountered. Fourteen total species were found in Orchard Bog. This was the most diverse site regarding both anuran and caudate species. The most abundant species found within Orchard Bog was *Pseudacris crucifer* and *Ambystoma maculatum.*

Table 3 Species Occurrence per Study Area

Species	Orchard Bog	Quarry Bog	Control
Bufo americanus	■	■	■
Hyla chrysoscelis / versicolor		■	
Pseudacris crucifer	■	■	■
Rana clamitans	■	■	
Rana palustris	■		
Rana sylvatica	■	■	
Rana catesbeiana	■	■	■
Desmognathus ochrophaeus	■	■	
Desmognathus fuscus	■	■	

Table 3 (continued)

Species	Orchard Bog	Quarry Bog	Control
Eurycea wilderae	■		
Plethodon cylindraceus		■	
Plethodon yonahlossee	■		
Pseudotriton ruber	■		
Gyrinophilus porphyriticus	■		
Ambystoma maculatum	■	■	
Notophthalmus viridescens	■		
	14 species	10 species	3 species

Spring salamanders, *Gyrinophilus porphyriticus*, were only observed in Orchard Bog near a culvert opening and were identified on 9 of 33 survey visits. Other caudate species that were only found within the Orchard Bog study area included *Eurycea wilderae, Plethodon yonahlossee, Pseudotriton ruber,* and *Notophthalmus viridescens.* Both *Plethodon yonahlossee* and *Notophthalmus viridescens* were found in more terrestrial locations. *Plethodon yonahlossee* was observed on only three occasions within Orchard Bog in close proximity to the woodlot perimeter near dusk. Only one individual was observed on each occasion. Two were identified on separate occasions in April 2003 and one was observed in May 2003. *Notophthalmus viridescens* was only observed on one site visit during what appeared to be a Red Eft migration period. Over 70 individuals were captured and released during an opportunistic survey that occurred during September of 2002.

Eurycea wilderae and *Pseudotriton ruber* were found in a variety of locations throughout Orchard bog. The Blue Ridge Two-lined Salamander was found in considerably drier areas on four of the six occasions they were observed. These observations took place during summer months of 2002. Two separate observations took place in April of 2002 and late March of 2003. Species were identified on the pasture side of the bog near stream areas.

Four species of caudates were observed in Quarry Bog. These included *Desmognathus ochrophaeus, Desmognathus fuscus, Plethodon cylindraceus, and Ambystoma maculatum*. *Desmognathus ochrophaeus*, being more terrestrial than several other species (Conant and Collins 1998), were found in mesic areas of the bog but not in standing pools or in the stream area. Both *Desmognathus ochrophaeus* and *Desmognathus fuscus* were also documented in Orchard Bog and were found on numerous visits within both habitats. *Desmognathus fuscus* were found on all occasions near aquatic portions of the habitat. *Plethodon cylindraceus* was only observed in Quarry Bog. This was one of the least recorded species with only five individuals observed. *Ambystoma maculatum* was also observed in Quarry Bog as well as Orchard Bog. Numerous egg masses of *A. maculatum* were found in both bogs with majority found in areas of surrounding vegetation.

Six of the seven species of anurans identified were recorded in Orchard Bog. These included *Bufo americanus, Pseudacris crucifer, Rana clamitans, Rana palustris, Rana sylvatica,* and *Rana catesbeiana.* *Pseudacris crucifer* was the most encountered species within the habitat and was identified during 97% of survey visits. First aural and visual identification occurred in March of 2002. This is one of three species identified in all three study areas including the control site. *Rana palustris* was captured on numerous occasions within Pitfall traps within Orchard Bog. They were identified in 95% surveys that occurred between March and May of 2002 and 2003.

Rana catesbeiana were identified in Orchard Bog and Quarry Bog as well as one of three species encountered in the control on multiple occasions. They were trapped in pitfall traps as well as encountered in visual surveys throughout both bogs and the control site. *Rana sylvatica* and *Rana clamitans* was identified on several occasions in both Orchard and Quarry Bogs. Neither species was captured in pitfall or funnel traps but were observed aurally and visually. On multiple instances, *Rana sylvatica* eggs were very conspicuous in smaller streams and slower moving water surrounding Orchard Bog. The third species identified in all study areas was *Bufo americanus*, American Toad. This species was captured on eight occasions within pitfall traps located in Orchard Bog.

A species of treefrog was identified only in Quarry Bog habitat. This species was identified nine times during the study with four positive identifications in the months of May and June of 2002 and five observations in May and June of 2003. Table 4 shows the percentage of time each species was encountered at individual study sites.

Table 4 Percentage of Time Species Were Encountered in All Surveys

Total # of Surveys = 33

	Orchard Bog	% time encountered	Quarry Bog	% time encountered	Control	% time encountered
Spring Peeper – *Pseudacris crucifer*	32	97.0%	27	81.8%	30	60.6%
Pickerel Frog – *Rana palustris*	21	63.6%	0	0.0%	0	0.0%
American Toad – *Bufo americanus*	17	51.5%	16	48.5%	12	36.4%
Bullfrog – *Rana catesbeiana*	24	72.7%	12	36.4%	7	21.2%
Gray Treefrog / Copes Gray Treefrog – *Hyla versicolor / Hyla chrysoscelis*	0	0.0%	9	27.3%	0	0.0%
Wood Frog – *Rana sylvatica*	9	27.3%	6	18.2%	0	0.0%
Green Frog – *Rana clamitans*	20	60.6%	23	69.7%	0	0.0%
Mountain Dusky Salamander – *Desmognathus ochrophaeus*	17	51.5%	23	69.7%	0	0.0%
Northern Dusky Salamander - *Desmognathus fuscus*	12	36.4%	14	42.4%	0	0.0%
Blue Ridge Two-lined Salamander- *Eurycea wilderae*	6	18.2%	0	0.0%	0	0.0%
White-Spotted Slimy Salamander – *Plethodon cylindraceus*	0	0.0%	5	15.2%	0	0.0%
Yonahlossee Salamander - *Plethodon yonahlossee*	3	9.1%	0	0.0%	0	0.0%

Table 4 (continued)

Red Salamander – *Pseudotriton ruber*	4	12.1%	0	0.0%	0	0.0%
Spring Salamander – *Gyrinophilus porphyriticus*	9	27.3%	0	0.0%	0	0.0%
Spotted Salamander – *Ambystoma maculatum*	19	57.6%	6	18.2%	0	0.0%
Red-Spotted Newt – *Notophthalmus viridescens*	1	3.0%	0	0.0%	0	0.0%

An index of community similarity is a good way to compare various assemblages. This index ranges from 0 to 1.0 to quantify a range from no similarity to complete similarity (Krebs, 1972). All sites differed in the number of anurans and caudates present. The indices of similarity were calculated between Orchard and Quarry Bog as well as Orchard Bog and the Control and Quarry Bog and the Control. These results showed that there was a moderately high index of similarity between Orchard Bog and Quarry Bog with greater than .65 total similarity (Table 5). Low similarity was shown between Orchard Bog and the Control with an index of .35 (Table 6) and .42 between Quarry Bog and the Control (Table 7).

Table 5 Index of Similarity between Orchard Bog and Quarry Bog

	Number of Species Orchard Bog (a)	**Number of Species Quarry Bog (b)**	**Species in Common (both sites) (C)**	**Similarity Value**
Anurans	6	6	5	.83
Caudates	8	4	3	.50
Total Amphibian Species	14	10	8	.66

Similarity Value = 2C/ (a+b)
C = # of species in common
a = number of species in site a
b = number of species in site b
(Krebs 1972 p.402)

Table 6 Index of Similarity between Orchard Bog and Control

	Number of Species Quarry Bog (a)	**Number of Species Control (b)**	**Species in Common (both sites) (C)**	**Similarity Value**
Anurans	6	3	3	.66
Caudates	5	0	0	0
Total Amphibian Species	11	3	3	.42

Similarity Value = 2C/ (a+b)
C = # of species in common
a = number of species in site a
b = number of species in site b
(Krebs 1972 p.402)

Table 7 Index of Similarity between Quarry Bog and Control

	Number of Species Orchard Bog (a)	**Number of Species Control (b)**	**Species in Common (both sites) (C)**	**Similarity Value**
Anurans	6	3	3	.66
Caudates	8	0	0	0
Total Amphibian Species	14	3	3	.35

Similarity Value = 2C/ (a+b)
C = # of species in common
a = number of species in site a
b = number of species in site b
(Krebs 1972 p.402)

Orchard Bog

Although the number of anuran and caudate species were the same with four species of each, there were more individuals of anuran species captured in pitfall traps. Of the four species of anurans, 318 individual frogs were collected while only 70 individual salamanders were captured in the nine traps. The most abundant species of both anurans and caudates was *Pseudacris crucifer* (Table 8). *Pseudotriton ruber* was found to be the least abundant with only three individuals captured.

Table 8 Relative Species Abundance of Amphibians in Orchard Bog

Species	Number of Individuals	Relative Abundance
Spring Peeper – *Pseudacris crucifer*	228	0.600
Pickerel Frog – *Rana palustris*	36	0.095
American Toad – *Bufo americanus*	8	0.021
American Bullfrog – *Rana catesbeiana*	23	0.061
Spotted Salamander – *Ambystoma maculatum*	53	0.139
Northern Red Salamander– *Pseudotriton ruber*	3	0.008
Mountain Dusky Salamander – *Desmognathus ochrophaeus*	20	0.053

Table 8 (continued)

Northern Dusky Salamander – *Desmognathus fuscus*	8	0.021
Spring Salamander - *Gyrinophilus porphyriticus*	1	0.053
Total	380	1.000

When determining habitat usage in Orchard Bog, Traps 1, 2, and 3 were located in the Beaverdam Creek area. Traps 4, 5, and 6 were adjacent to the pasture habitat and traps 7, 8, and 9 were adjacent to the wooded area of Orchard Bog. Each pitfall trap had a corresponding funnel trap located within the same area. The area found adjacent to the pasture habitat captured the highest number of individuals with 139 being identified. The traps located along the Beaverdam Creek area trapped the next highest number of individuals with 131 being captured (Table 9).

Table 9 Amphibians Captured in Orchard Bog Pitfall Traps

Total number of amphibians caught in Orchard Bog pitfall traps										
SPECIES	TRAP #									TOTAL
	1	2	3	4	5	6	7	8	9	
Spring Peeper – *Pseudacris crucifer*	37	51	12	9	42	7	22	19	5	204
Pickerel Frog – *Rana palustris*	5	-	2	-	6	8	2	-	3	26
American Toad – *Bufo americanus*	-	1	4	1	-	-	1	1	-	8
American Bullfrog – *Rana catesbeiana*	1	-	3	-	12	-	-	-	7	23

Table 9 (continued)

SPECIES	TRAP #									TOTAL
	1	2	3	4	5	6	7	8	9	
Spotted Salamander – *Ambystoma maculatum*	7	2	5	-	20	1	2	-	8	45
Northern Red Salamander– *Pseudotriton ruber*	-	-	-	-	-	2	1	-	-	3
Mountain Dusky Salamander – *Desmognathus ochrophaeus*	1	-	-	-	3	-	6	-	4	14
Northern Dusky Salamander – *Desmognathus fuscus*	-	-	-	-	2	-	2	1	3	8
TOTAL	51	54	26	10	85	18	36	21	30	331
TOTAL PER AREA	Σ of traps 1,2 and 3 131			Σ of traps 4, 5 and 6 113			Σ of traps 8, 9 and 10 87			

Traps 1-3 – Beaverdam Creek Area
Traps 4-6 – Pasture Area
Traps 7-9 – Woodlot Area

Capture of anurans and caudates in funnel traps was low. It is thought that location and varying water levels caused little success with this trapping method. Though five species were captured, only 12% or 49 individuals of those that were captured in pitfall traps were captured in funnel traps. Funnel traps that were placed in Beaverdam Creek captured no individuals. The most abundant species captured of both anurans and caudates was *Pseudacris crucifer* with 24 individuals (Table 10).

Table 10 Amphibians Captured in Orchard Bog Funnel Traps

Total number of amphibians captured in Orchard Bog funnel traps										
Species	Trap #									TOTAL
	1	2	3	4	5	6	7	8	9	
Spring Peeper – *Pseudacris crucifer*	-	-	-	3	5	7	3	-	6	24
Pickerel Frog – *Rana palustris*	-	-	-	1	6	2	1	-	-	10

Table 10 (continued)

Species	Trap #									TOTAL
	1	2	3	4	5	6	7	8	9	
Spotted Salamander – *Ambystoma maculatum*	-	-	-	-	2	-	1	3	2	8
Mountain Dusky Salamander – *Desmognathus ocrophaeus*	-	-	-	-	-	-	1	3	2	6
Spring Salamander – *Gyrinophilus porphyriticus*	-	-	-	-	-	-	-	-	1	1
TOTAL				4	13	9	6	6	11	49
TOTAL PER AREA	Σ of traps 1, 2, and 3 0			Σ of traps 4, 5 and 6 26			Σ of traps 7, 8 and 9 23			

Traps 1-3 - Beaverdam Creek Area
Traps 4-6 – Pasture Area
Traps 7-9 – Woodlot Area

When both the pitfall and funnel trap data were combined, it showed that 131 individuals were captured bordering the pasture area (Figure 5). This was similar to the Beaverdam Creek border area where 139 individuals were captured. One factor that influenced these data was that funnel traps were unsuccessful along Beaverdam Creek.

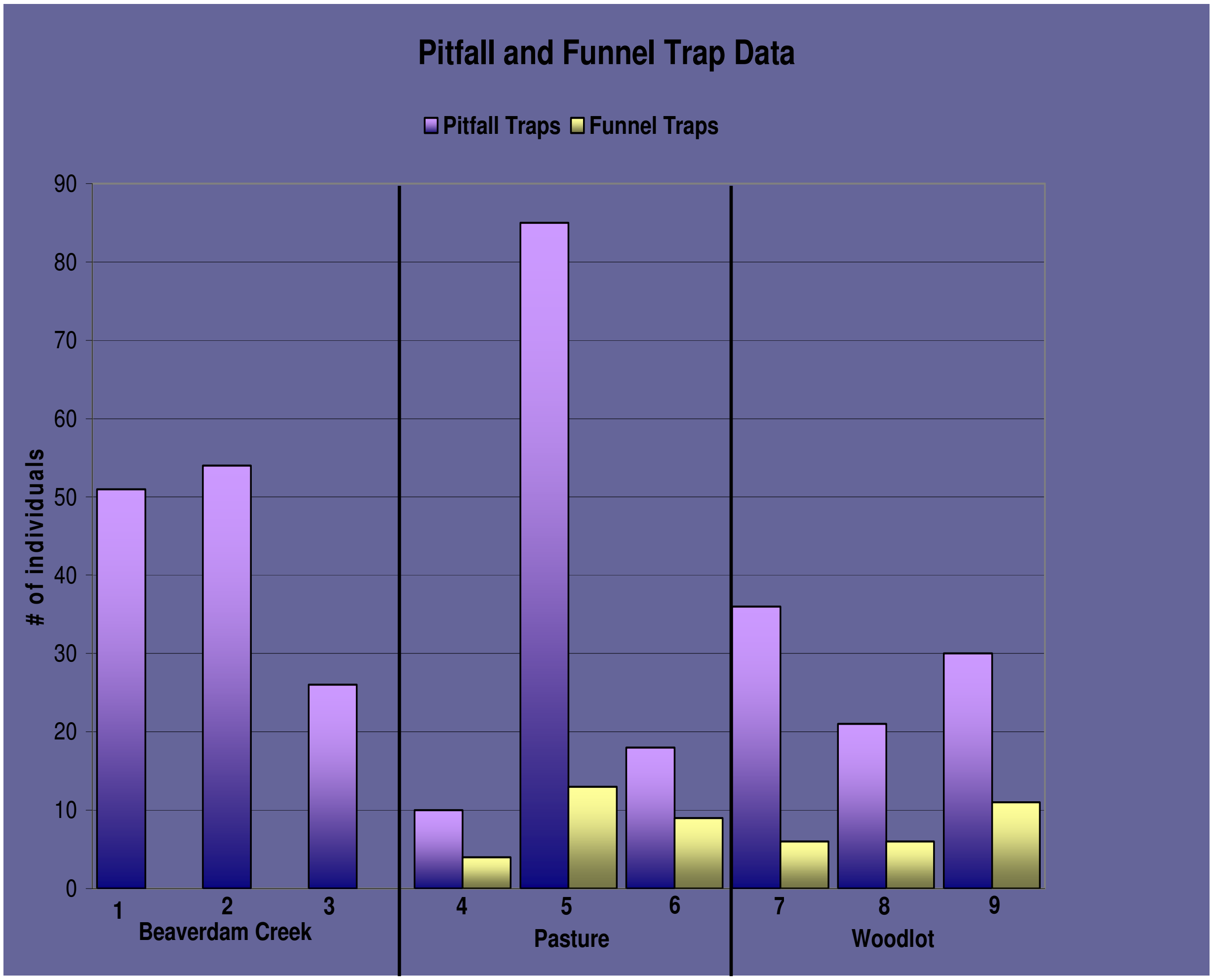

Figure 5 Number of Individuals Captured in Pitfall and Funnel Traps

Individual pitfall and funnel trap data were further analyzed by calculating means and standard error as well as a one-way analysis of variance (ANOVA) using the computer program SPSS (SPSS, Inc. 2007) (Table 11). Results of the ANOVA indicate there is no significant difference between numbers of individuals captured and trap location with a p value of .622. Data were then graphed illustrating numbers of captured individuals per trap (Figure 6).

Table 11 Individual Pitfall and Funnel Trap Data

	Trap 1	Trap 2	Trap 3	Trap 4	Trap 5	Trap 6	Trap 7	Trap 8	Trap 9
Mean	10.2	18	5.2	3.6	11.1	5.14	4	5.5	4.73
SD	15.21	28.58	3.96	3.29	12.29	3.34	5.95	6.86	3.04
SEM	± 6.8	± 16.5	± 1.77	± 1.47	± 3.89	± 1.26	± 1.72	± 2.8	± 0.92

ANOVA	Sum of Squares	df	Mean Square	F	Sig.
Between Groups	373.197	8	46.650	.779	.622
Within Groups	6470.615	108	59.913		
Total	6843.812	116			

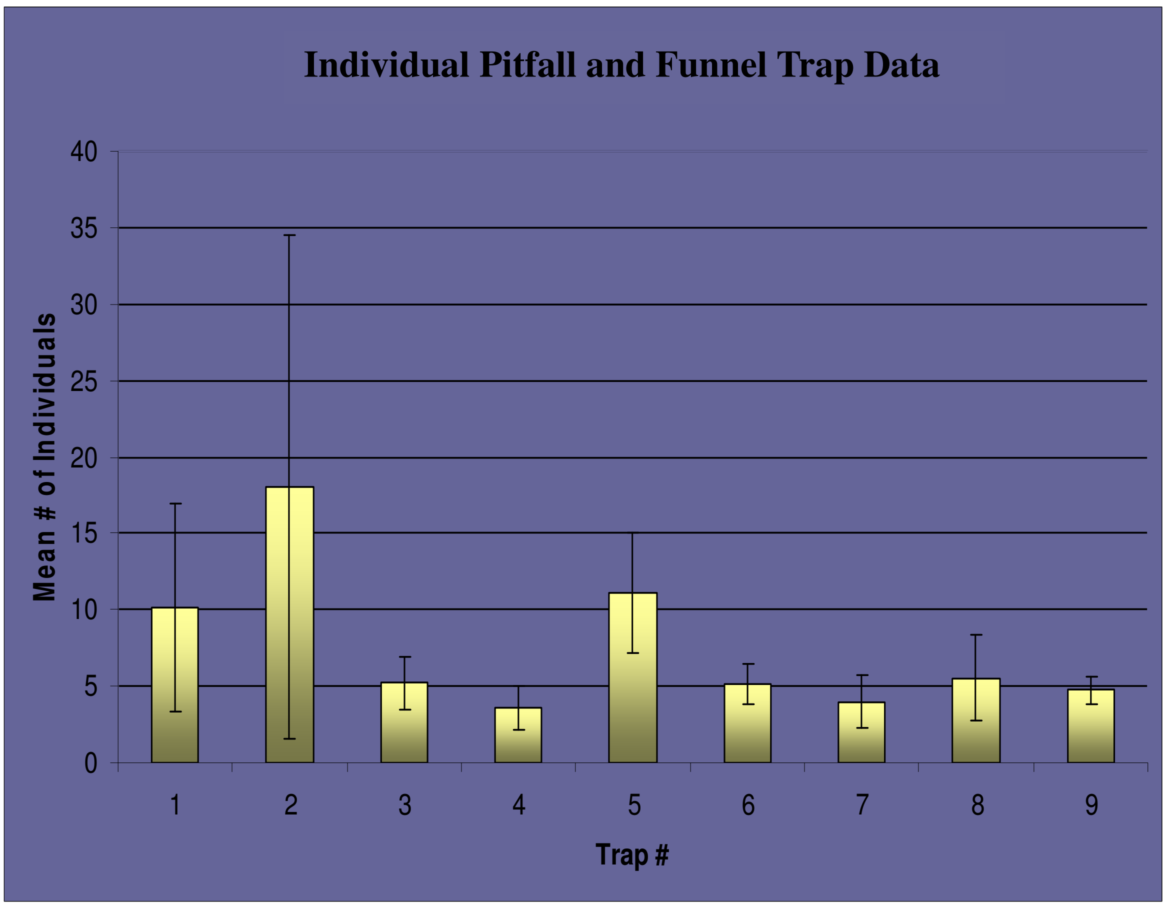

Figure 6 Individual Pitfall and Funnel Trap Data

Data were then combined based on habitat type (Beaverdam Creek, Pasture, and Woodlot). Data were again analyzed using a one-way ANOVA (Table 12). With a p value of .909 there was no significant difference shown between numbers of individuals captured between the three different habitat types. This is illustrated graphically in Figure 7.

Table 12 Combined Pitfall and Funnel Trap Data

	Traps 1- 3 Beaverdam Creek		Traps 4-6 Pasture		Traps 7-9 Woodlot
Mean	10.1		7.5		4.6
Standard Deviation	15.6		9.0		5.1
SEM	± 4.3		± 1.9		± 1.0

ANOVA	Sum of Squares	df	Mean Square	F	Sig.
Between Groups	11.504	2	5.752	.096	.909
Within Groups	6832.308	114	59.933		
Total	6843.812	116			

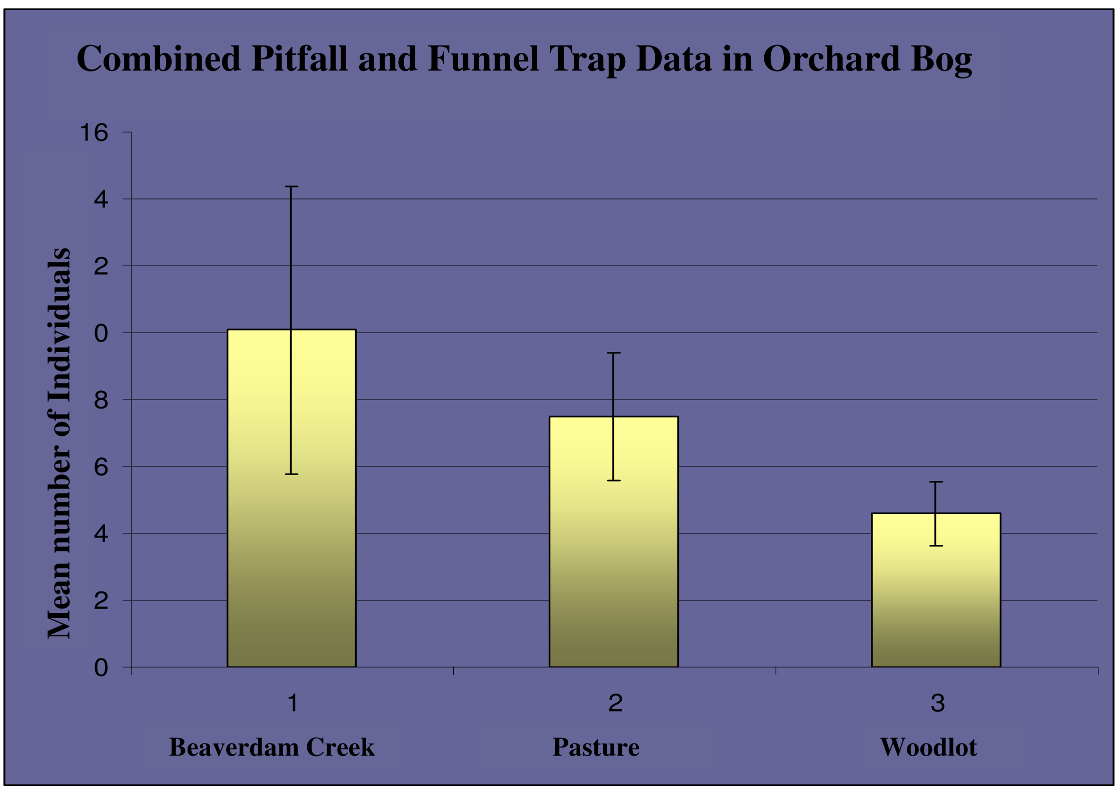

Figure 7 Combined Pitfall and Funnel Trap Data in Orchard Bog

Coverboards

Capture of species under coverboards was highly variable throughout Orchard Bog. Factors that are thought to have added to the variation in the data was the time of day in which sampling occurred, length of time in which cover boards were placed in habitat, and moisture fluctuations (Fellers and Drost 1988). During the 2002 sampling season, weather was extremely dry with only minimal amounts of rainfall. During the 2003 season incorporating the months of March thru July, precipitation levels totaled 28.76 inches. During the same months of 2002 levels were 16.01 inches (AccuWeather . . . [updated 2007]). Coverboards that were in dry areas in 2002 were completely submerged during the 2003 sampling season. Some boards were also difficult to locate due to fast-growing vegetation in some areas. Data from this sampling method were inconclusive and were not included within the results section. No species were found under coverboards that were not found using other sampling methods.

CHAPTER 4

DISCUSSION

Community Similarity and Species Occurrence

With a moderately high index of similarity, greater than .65, Orchard Bog and Quarry Bog supported somewhat similar amphibian assemblages. Similarities were expected even with the differences in age of restoration area due to both areas being comparable in the environmental factors measured. However, fewer individual caudates were captured in Quarry Bog than in Orchard Bog which was most likely attributed to lack of the naturally occurring cover objects and overall restoration age was shorter.

The four species of caudates, *Desmognathus ochrophaeus, Plethodon cylindraceus, Ambystoma maculatum*, and *Desmognathus fuscus*, observed in Quarry Bog were characteristic of habitat present. Consistent with what was reported by Wells (1980), Plethodon *cylindraceus* was found near rotting logs and debris in late spring and early summer of 2001 and 2002. Larvae of *Plethodon cylindraceus* has no aquatic stage, instead, total development occurs within the egg (Conant and Collins 1994). Though only found on limited occasions within Quarry Bog, it is not understood why this species was not detected within Orchard Bog. One possible explanation may be that more suitable habitat for this species was found outside the study area of Orchard Bog that was surveyed.

On several occasions egg masses of *Ambystoma maculatum* were attached to sticks or partially submerged vegetation as was expected (Semlitsch 1990). Egg masses and individuals were observed by early March of 2001. In 2002 egg masses were not present until early April. These observations are consistent with published data (Semlitsch 1990; Petranka 1998).

It is noted that *Desmognathus fuscus* do not readily migrate long distances and typically live within a few feet of streams and springs (Hom 1987). This species is often and easily confused with the Mountain Dusky Salamander, *Desmognathus ochrophaeus.* Identification was confirmed to be Northern Dusky by the keeled tail rather than the rounded tail of the Mountain Dusky (Conant and Collins 1998).

Gyrinophilus porphyriticus has an aquatic larval phase and has been reported in open areas, ponds, lakes, and peat habitats (Petranka 1998). They are known to be voracious predators and have shown to be cannibalistic in southern populations (Bruce 1972); however, this behavior was not observed during this study.

The Yonahlossee Salamander can be found in a variety of different habitats ranging from forests to springs (Conant and Collins 1994). *Notophthalmus viridescens* can have a terrestrial eft stage of development during which time they are known to migrate from forested terrestrial sites into aquatic habitat where they become reproductively mature (Hurlbert 1970). At the time individuals were identified, all seemed to be moving towards aquatic habitat which seemed uncharacteristic. By further examining other literature, it is noted that efts may have a spring and fall migration to breeding sites (Healy 1975).

It has been reported that adult *Eurycea wilderae* can be found considerable distances from water (Huheey and Stupka 1967); however, eggs and larvae are aquatic. Although *Pseudotriton ruber* is also found in both aquatic and terrestrial habitat types, (Redmond and Scott 1996), during this study all observed individuals were in semi-aquatic portions of the bog.

Pools and ponds are necessary for survival of all species of frogs and toads in Northeast Tennessee. These areas of open water are used for egg deposition. All anurans found within study sites were consistent with published data for eastern Tennessee. *Pseudacris crucifer* was found to be active in March of both 2002 and 2003, when surveys began. *Pseudacris crucifer* remained active for the majority of study. On all but one occasion in Orchard Bog species were visually identified. It should be noted that of the five surveys in Quarry Bog where *P. crucifer* were not recorded, calling individuals were heard but were never visually encountered.

Rana palustris was captured most often during what has been reported as breeding season, March to May, of both trapping years (Green and Pauley 1987). During early portions of the study it was reported that Southern Leopard Frog, *Rana utricularia,* had been identified. After consulting numerous literature resources as well as additional field guides, it was determined these species had been misidentified and were actually *Rana palustris*.

On several occasions, *Rana sylvatica* was identified in both Orchard Bog and Quarry Bog. It has been reported that breeding migrations have been recorded in February in Tennessee. *Rana sylvatica* migrate from terrestrial overwintering sites to seasonal breeding wetlands. (Meeks and Nagel 1973). During this study, species were identified in March and April of both study years and were found in both terrestrial and aquatic habitat types which are consistent with published literature (Conant and Collins 1998).

During all observations in Quarry Bog, *Hyla versicolor* or *Hyla Chrysoscelis* were found in and around mesic grasslands near the middle of the study site. *Hyla versicolor* and *Hyla chrysoscelis* are essentially indistinguishable in the field and accurate identification cannot be done visually (Conant and Collins 1998). In the laboratory, chromosome numbers of the species can be determined, therefore species identified. *Hyla versicolor* has twice the number of chromosomes as *Hyla chrysoscelis* (Redmond and Scott 1996). Because no laboratory analysis was done, it was undetermined which of the two species was observed during this study.

Study Methods

Many studies have shown the varied effectiveness of the study methods including pitfall traps with drift fences, funnel traps, and coverboards, but they have been used successfully to capture a variety of species (Christiansen and Vandewalle, 2000). Most have or recommend establishing a drift fence completely around the study area. Due to the various habitat types, size of habitat area being studied, lack of manpower, as well as being cost prohibitive, this was not done during this study. Though pitfall traps and funnel traps are effective, even in limited arrays, entire coverage of the study area would most likely produce greater capture rates. In previous studies, funnel traps have been found to be equally or more effective than pitfall traps when capturing herpetofauna (Enge 2001).

Coverboards were chosen as a sampling method due to the many advantages of using an artificial cover method. Though this method was not superior in this study at capturing species or individuals, this method is often looked upon favorably when compared to drift fences because they are relatively inexpensive to construct and maintenance is virtually non-existent (Ryan et al. 2002). However, the disadvantages of changing habitat due to fluctuations in water levels and rapidly growing vegetation made it less successful then was originally expected.

This is not to say that coverboards are not an effective way of monitoring amphibians. There are several advantages to coverboards when comparing them with other surveying methods. It allows for a standard number of cover objects that are of uniform size, minimal variability would exist between individuals observing species, coverboards are typically more sturdy than a lot of natural objects, minimal cost is involved, minimal training is required, and maintenance is almost non-existent (Fellers and Drost 1988). This survey method has been successful in contributing data when measuring abundance and in some studies has been able to detect species that were unobserved by other techniques (Ryan et. al. 2002).

Because mark and recapture methods were not implemented, it is not possible to determine if individuals identified on more than one survey visit were observed in previous visits. These methods were not implemented because population size estimates were not part of the study. This study, instead, was designed to compare presence/absence data. It has since been determined this would have made a more effective study allowing density estimates as well as relative abundance and species richness to be determined (Heyer et al. 1994).

Habitat Usage

The aquatic portion of a resource habitat is often protected by environmental agencies but the surrounding habitat is frequently overlooked. These surrounding areas are critical for species persistence over extended amounts of time (Roe, 2007). Since the time of this study, several tracts of land surrounding the bog have been added to the project. Properties adjacent to Beaverdam Creek as well as adjacent to previously existing pasture have been added to the preserve.

By further examining habitat usage between varying habitat types, conservation efforts can be prioritized and focused on habitats with the largest or most diverse amphibian populations. This information may also be used to aid in future management decisions.

It was originally hypothesized that a larger number of species would be found using the pasture side of the study site at Orchard Bog. However, when examining individual trap data, analysis showed that there was no significant difference between traps located on the pasture side of the study area from other nearby traps. Also, when trap data were combined comparing the pasture, woodlot, and creek side of the surrounding habitat, no significant difference was present in numbers of individuals captured. It was also hypothesized that numbers from the Beaverdam Creek side of the study area would be lowest due to the levels and velocity of the water. Beaverdam Creek may have served as a natural drift fence helping to funnel species to the trap arrays.

Though an increased number of amphibians were shown to use areas from the surrounding pastureland, numbers were found to be similar coming from the terrestrial upland forest/woodlot area. The forest/woodlot area of Orchard Bog was initially thought to be completely terrestrial, but during periods of increased rain it did retain water. This may have increased the opportunity for this area to serve as habitat for many of the caudate species that use multiple habitat types during their life cycles and may have prevented many of them from progressing into the core habitat where traps were located. It is unclear if this caused a significant decrease in the number of individuals trapped along this area

Drought conditions as well as sampling error may have also affected number of species captured. Other studies have shown that terrestrial reptiles will travel extended distances to avoid pitfall traps (Christiansen and Vandewalle 2000). Though this has not been shown to be true with amphibians, drift fences in combination with pitfall traps have shown to be a very successful method of trapping, (Heyer et al. 1994; Christiansen 2000; DeGraaf and Rudis 1990). However, the concept of trap avoidance should not be dismissed. Drift fences also had to be checked and repaired regularly due to small mammals burrowing under them, and on two separate occasions as a result of deer running though the drift fences. This was confirmed by presence of tracks, feces, and hair.

All three surrounding habitats prove to be significant feeders or secondary habitat to Orchard Bog. I also believe if more encompassing trap arrays were used and additional survey methods, outcomes may have been different. When this study was conducted one goal was to determine which areas would be most imperative to focus on for future land acquisitions. After data were analyzed, it could be concluded that all three surrounding areas were found to be of great importance. Though the data did not show a significant difference between the numbers of species using surrounding habitat types, it does solidify the importance of protecting not only core or aquatic areas but to also include outlying terrestrial habitat in order to protect the full realm of biodiversity of an area.

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